Colored Concrete: Does it Deliver the Goods?

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- Gerard Moulzolf – American Engineering Testing, Inc.
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Colored Concrete

Why use it on or near roads?

- Architectural effects: “Streetscaping”
- Safety: Delineation

Streetscaping

Streetscaping

Streetscaping

Delineation

Delineation

Delineation

- Looks great!.....but costs more!

- *Does it "deliver the goods?"*

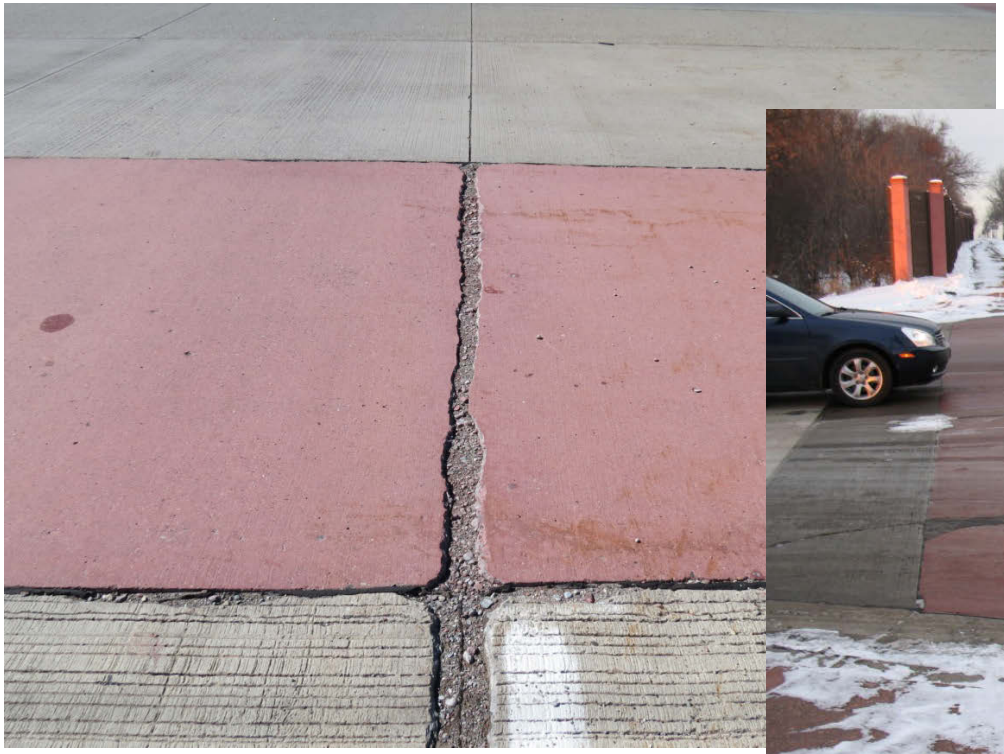
Unfortunately, there's TROUBLE brewin'…

And it's called:

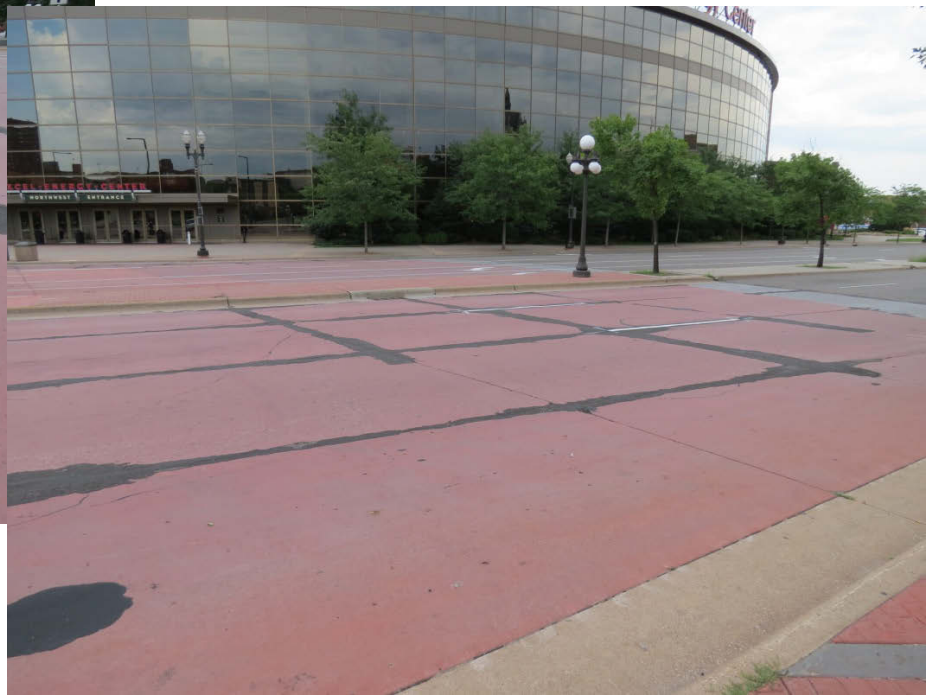
Early Joint Distress

Cty Hwy 14, Main Street, Centerville

Hwy 96, Vadnais Heights



Some Low Profile Location…



Potential Causes

- Construction practices
  - "Hand" placement
  - Over-finishing surface
  - Lack of proper curing
- Materials related reduction in durability
  - Low air content (less freeze/thaw resistance)
  - Low strength
  - Poor paste-to-aggregate bond
  - Pigment related incompatibilities

Potential Causes

- Chemical attack
  - Pigment reactions
  - Deicing chemicals

- Project design
  - Slow drainage and minimal slopes
  - Loss (or lack) of joint sealant

LRRB Investigation 929

Investigation and Assessment of Colored Concrete Pavement

- 2 year study (2012-2013)
- Principal Investigators:
  - Ally Akkari - MnDOT
  - Tom Burnham – MnDOT
- Subcontractor – American Engineering Testing, Inc.
  - Gerard Moulzolf

Project Tasks

- Locate projects
- Investigate extent of problem
- Observe construction practices
- Petrographic Analysis
- Examine materials (lab study)
- Look at associated maintenance practices
- Investigate potential repairs

Work Completed

Ø Database of projects with colored concrete

- Found 50 projects so far, statewide
- Communities include:

Apple Valley, Arden Hills, Barnesville, Baxter, Brainerd, Brooklyn Center, Burnsville, Centerville, Columbia Heights, Detroit Lakes, Forest Lake, Grand Rapids, Maplewood, Minneapolis, Otsego, Park Rapids, Princeton, Roseville, Sauk Rapids, Shoreview, St. Paul, St. Anthony, Staples, Thief River Falls, Vadnais Heights, Stillwater

Observations of Performance

Ø Good to fair

- Many projects recently completed
- Distresses focused on joint regions
- Some cracking, possibly due to thermal expansion restraint
- Smooth textures
- Plow damage

Good Performance

Benton Dr and 2nd St, Sauk Rapids (Built 2007)

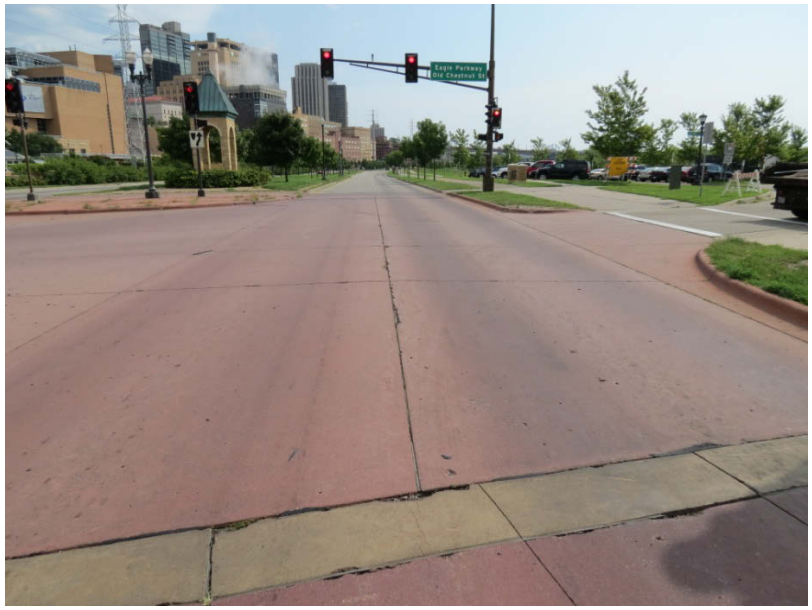
Good Performance

Cty Rd C and Cleveland, Roseville (Built 2006)

Fair Performance

Phalen Blvd and Payne Ave, St. Paul (Built ?)

Fair Performance



Shepard Rd and Old Chestnut St., St. Paul (Built ?)

Observed Construction Practices

- Most used “hand” placement
  - Leveled with 2x4 lumber
  - Little to no consolidation effort
  - Struck off and finished with multiple passes of steel trowel
  - Hand tooled joints or edges
  - Sometimes “blessed” to keep the surface workable
  - Smooth finish
  - Curing method sometimes optional

Observed Construction Practices

- Some locations required additional steps to change color in field
  - Shake on color powder w/ Confilm
  - Colorwax/curing compound

Observed Construction Practices

- Ø Fresh colored concrete samples taken by research staff
  - Results typically indicated adequate air content and flexural strength

Petrographic Analysis of Cores

- Took core samples from 4 projects exhibiting early joint distress
  - Main Street, Centerville
  - Cty Rd 96, Vadnais Heights
  - Lake Johanna Blvd, Arden Hills
  - Larpenteur and Fernwood, Roseville
- Sent to AET for petrographic analysis
  - Hardened air content
  - Microcracking (extent of distress)
  - Water to Cement ratio
  - Chemical attack

Cty Hwy 14, Main Street, Centerville

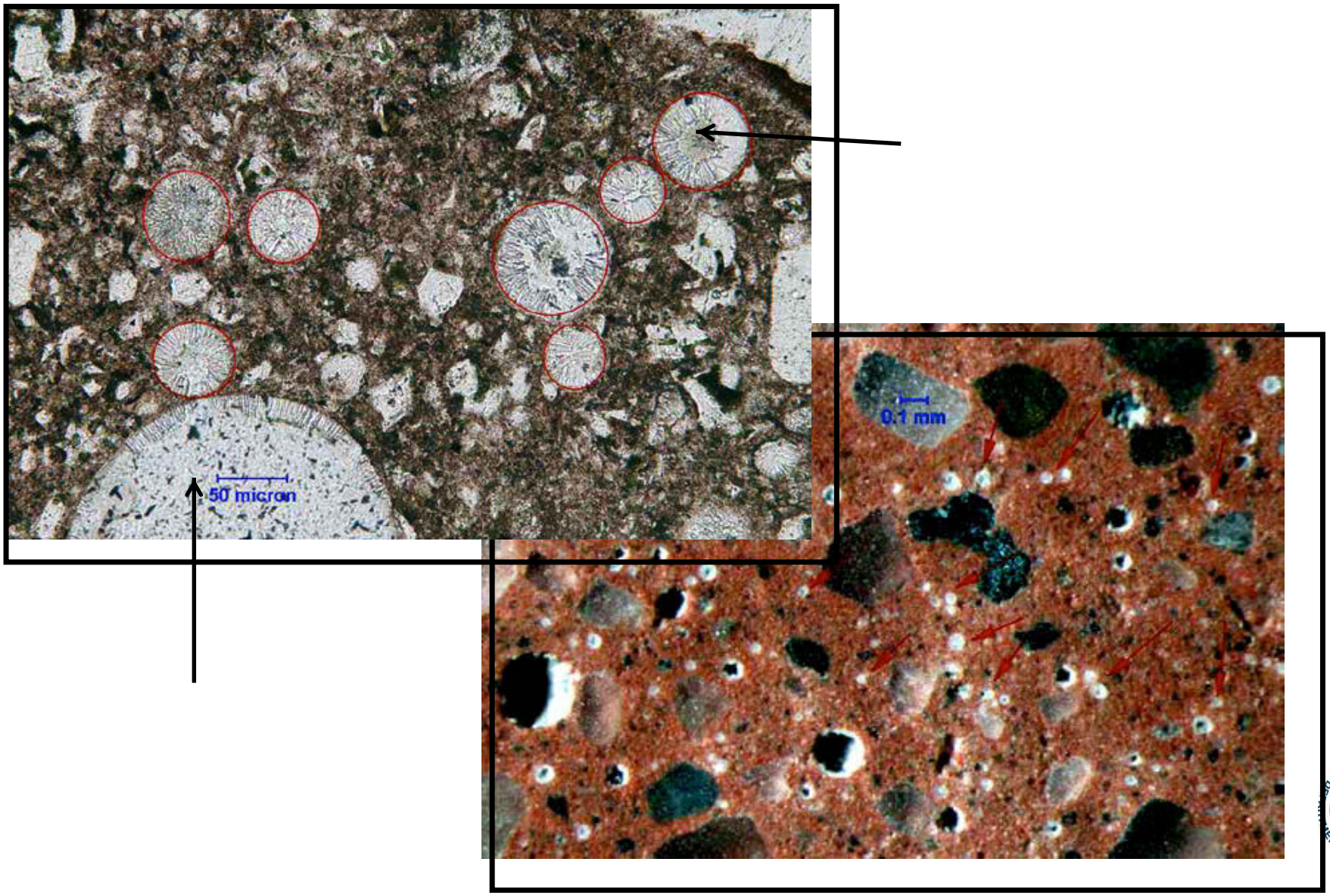
Constructed 2008

Petrographic Analysis Results

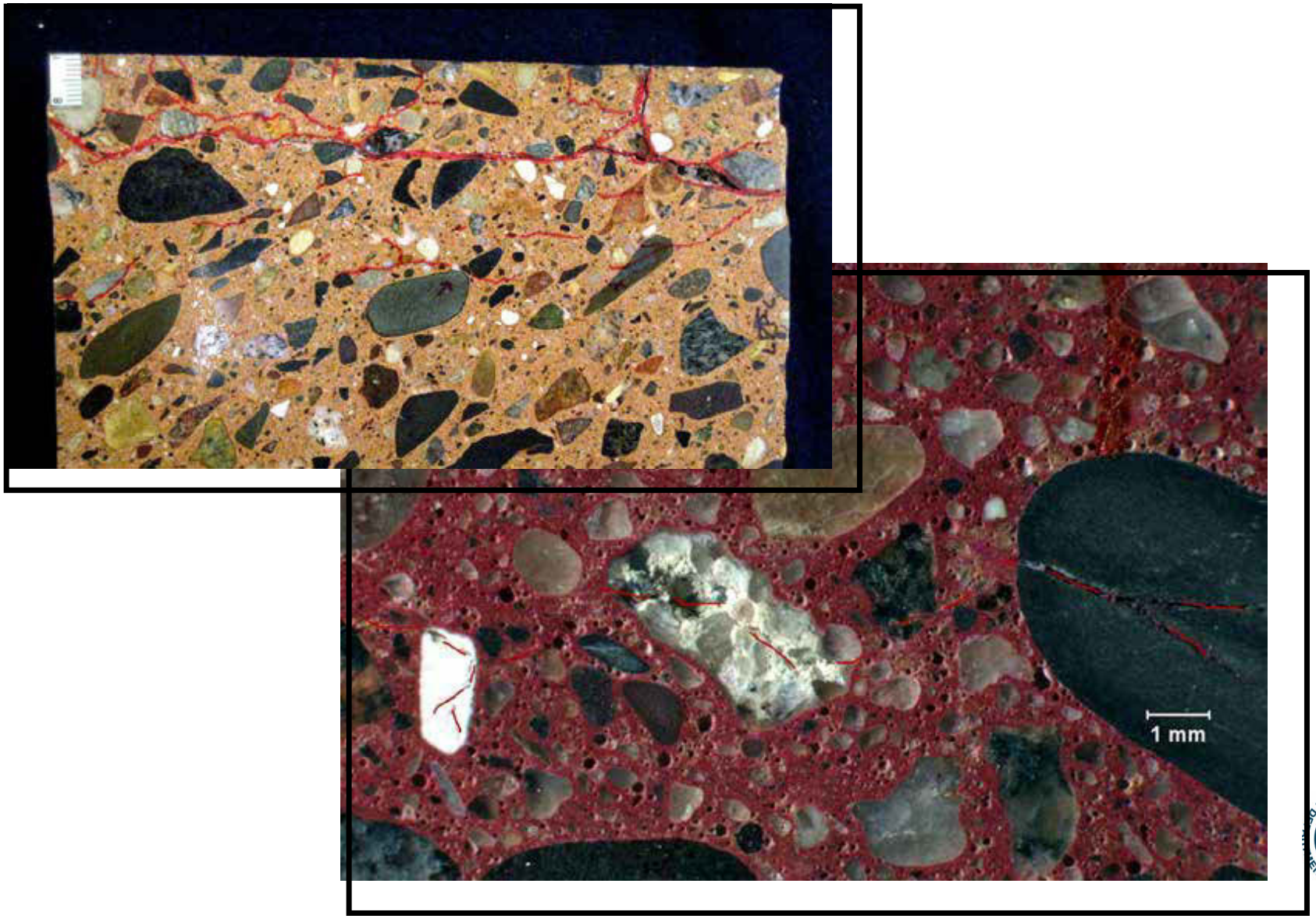
- Concentrated micro-cracking through the depth of the joints
- A poor bond between paste and aggregate
- High water to cement ratios (up to 0.50)
  - Paste has high porosity
- Initially adequate hardened air content system
  - System now filled with secondary ettringite near joints, significantly reducing freeze/thaw resistance
- Surprising presence of ASR in aggregates typically used for concrete in Minnesota
- Chemical alteration of paste
  - Possible chemical attack

Cty Hwy 14, Main Street, Centerville

Secondary Ettringite



Alkali Silica Reaction



Discussion

- Does not appear that recent placement and finishing techniques are the direct cause of the early distresses observed
- Most mixes appear to have too high a water to cement ratio for pavements located in Minnesota's extreme climate
- Presence of ASR is a concern, as behavior is occurring away from joints as well
- Cause of "chemical attack" needs to be investigated

Early Recommendations

- Design colored concrete mixes with low water to cement ratios (maximum= 0.40)
- Consider the effect certain deicers may have on increased saturation times in concrete joints
- Improve curing methods
- Provide good draining bases below concrete pavements
- Seal your joints and edges
- Improve safety of crosswalks and intersections with increased surface textures

What's next?

- Interim report to be released by end of March (Tech Brief available in lobby)
- Laboratory study to begin to determine causes for chemical attack
- Will develop improved design, construction, and maintenance guidelines for colored concrete pavements in Minnesota
- Will develop guidelines for potential repair techniques
- Final report December 2013

Questions?